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ECONOMIC EVALUATION OF THE ROLL ON/ROLL OFF ANCHOVY TRANSPORT SYSTEM

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INTRODUCTION

Growth of the skipjack tuna, *Katsuwonus pelamis*, industry in Hawaii is severely restricted by the availability of baitfish. Skipjack fishermen sacrifice from 35% to 40% of their potential fishing days competing for limited supplies of nehu, *Stolephorus purpureus*, the principal bait species now in use. Further, because nehu are extremely delicate no more than 75% of the nehu captured survive to be used as skipjack bait, and fishing trips of more than a day's length are not possible.

The scarcity and fragility of nehu not only limit the fishing time and range of the present fleet, but discourage investment in new vessels. Only one new vessel has joined the fleet in the past 20 years, while several boats have been retired.

Solution of the baitfish problem depends on success in two areas:

1. the technical development of alternative bait supplies at unit costs permitting substitution, and
2. the practical demonstration of the effectiveness of new baits and the building of confidence in their use among skipjack fishermen.

The second part of the solution requires that substitute baits be made available to skipjack fishermen in sufficient quantities to permit tests of key baitfish characteristics such as attractiveness to skipjack and survival in baitwells. The first part of the solution involves research in three areas:

1. appraisal of other local natural baitfish stocks (e.g., tilapia, _Tilapia_ spp., and threadfin shad, _Dorosoma petenense_;
2. local artificial propagation of potentially suitable baitfishes (e.g., topminnows, _Poecilia vittata_);
3. development of long-range transport methods to make available to local fishermen baitfishes of proven quality which are abundant elsewhere (e.g., northern anchovy, _Engraulis mordax_, from California).

This report summarizes a preliminary economic assessment of a long-range transport system recently developed by the Honolulu Laboratory of NMFS's Southwest Fisheries Center to convey northern anchovy from California to Hawaii. The system involves shipping anchovy in a specially modified aircraft fuel tanker aboard Roll on/Roll off (hereafter referred to as RO/RO) freighters.

EVALUATION OF SUBSTITUTE BAITS

OPPORTUNITY COST OF NEHU

The evaluation of alternative bait supplies in economic terms requires the construction of a substitution curve, which indicates the unit costs of various substitute baits relative to nehu at different usage rates (Wetherall, MS[2]). However, because nehu are not purchased as are, say, fuel and fishing lines there is no market mechanism to measure the value of nehu to skipjack fishermen. Instead the worth of nehu must be appraised in terms of its

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[2]Wetherall, J. A. Evaluation of bait substitution schemes in the Hawaiian fishery for skipjack tuna, _Katsuwonus pelamis_. Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812. Manuscript in preparation.

opportunity cost. Wetherall (MS[2]) has shown that the opportunity cost of nehu may be computed to a reasonable approximation as the product of three key factors:

1) the proportion of days spent baiting, 2) the ex-vessel price of skipjack, and 3) the amount of skipjack landed per unit of nehu used.

The feasibility of any alternative to nehu requires that the unit cost of that bait be no greater than the opportunity cost of nehu. Because the opportunity cost varies temporally a substitution scheme may not be feasible in all years or all seasons within a given year. Temporal variation in the opportunity cost of nehu is shown in Figures 1 and 2 and in Tables 1 and 2.

FEASIBILITY LINE

Two obvious conditions must be met to establish the feasibility of an alternative bait program during any time period: 1) as just discussed, the opportunity cost of nehu must not be less than the unit cost of the alternative bait, and 2) the quantity of bait produced by the scheme must not exceed the potential amount usable. Figure 3 shows how a particular hypothetical substitution scheme, producing bait at $4.50 per pound, generates a feasible period of about 7 months in an average year, 5 months in the spring and summer and 2 months at the end of the year. During this period, according to Table 2, about 190,000 pounds of bait could be used by the present skipjack fleet. For each point on the ordinate there is a different maximum usage rate. Together these form the feasibility line shown in Figure 4. Substitution schemes producing more bait than can be used or producing bait at a unit cost exceeding the opportunity cost of nehu will fall in the infeasible region to the right of the feasibility line. The feasibility line may also be interpreted as the demand curve for bait in the skipjack fishery.

Evaluation of the RO/RO system in terms of its impact on the present skipjack fleet is now straightforward. First we compute the unit costs of delivering various quantities of anchovy during different seasons, and judge the feasibility of each system using the feasibility line. Then, for all feasible configurations we determine the reduction in time spent pursuing nehu, the corresponding increase in skipjack fishing time and the expected net economic gain to the skipjack fleet. The analytical methods for these steps are described by Wetherall (MS[2]).

ANALYSIS OF UNIT DELIVERY COSTS IN THE RO/RO SYSTEM

THE RO/RO MODEL

Computing the unit costs of delivering anchovy via the RO/RO system requires the construction of a system model, which indicates the time sequencing of primary events of the RO/RO process and provides a framework for cost accounting. In the model used here the unit cost of delivering anchovy is a function of three factors: 1) the initial amount of bait purchased in California, 2) the overall bait survival rate, or the probability that any particular anchovy survives from purchase time until it can be used as live bait in Hawaii, and 3) the aggregate costs incurred in getting the bait to Hawaii. The third factor is of course directly related to the first two, and the second may depend on the first also.

The main events or stages of the RO/RO process are ordered as

1. Bait acquisition and aging
2. Loading and shipment
3. Offloading and usage.

Mortality takes place during each stage and is particularly acute during the transitional periods when the anchovy are stressed from handling and crowding. The instantaneous mortality rate during each stage may depend on several factors including the extent and manner of handling, loading density, size of the fish, condition of gonads, water temperature, dissolved oxygen concentration, and so on. Neither the individual effects of the key survival parameters nor their interactions are well understood in the context of the RO/RO system. Further, variability in survival rates may be high even under the best possible handling practices and elaborate environmental controls.

COSTS

Associated with the sequence of major events in the RO/RO process is a sequence of annual operating costs, which may be classified as follows:

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2. costs proportional to the number of aging units;

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3. costs proportional to the number of bait tankers;
4. costs proportional to the number of shipments;
5. costs proportional to the number of storage units;
6. costs proportional to the amounts of bait aged or stored; and
7. independent management and facilities costs.

In addition there are annual costs proportional to the total capital investment, such as depreciation, maintenance, insurance and debt service such as amortized capital expenses and interest. A detailed breakdown of estimated cost factors and the cost accounting for an example RO/RO system are presented in Table 3.

ASSUMPTIONS

In addition to the table of estimated cost factors, the analysis of the RO/RO system rested on a long list of assumptions, including

1. when aging is employed, anchovy are loaded into aging tanks at an assumed optimum density of 0.12 pounds per gallon (1,200 pounds per aging tank) and held for 20 days before shipment;
2. six aging tanks are required per tanker in the RO/RO system, when anchovy are aged;
3. only one RO/RO freighter is available, making one California-Hawaii round trip every 10 days;
4. up to four bait tankers may be transported on the RO/RO freighter during each crossing;
5. 1,700 pounds of anchovy are loaded into the tanker for each shipment (the assumed optimum load);

6. all anchovy delivered to Hawaii are used in skipjack fishing (i.e., no losses following delivery);
7. the difference in operating costs of skipjack vessel between a day spent fishing and a day spent baiting is $50;
8. the average amount of nehu in a bucket of bait, as reported by skipjack fishermen to the Hawaii Division of Fish and Game is 7 pounds;
9. pound for pound, anchovy are as effective as nehu in attracting skipjack;
10. the abundance of skipjack and the catch rate (pounds of skipjack caught per pound of nehu used) is equal to the 1968-73 average.

Some of these assumptions are relatively unimportant while others are critical to the final evaluations, as will soon be apparent.

ANALYTICAL PROCEDURE

The procedure adopted in the analysis of the RO/RO system was to

1. compute the expected amount of bait delivered and the cost per pound under many different configurations of the system (see below);
2. using the estimated feasibility line, determine the feasibility of each case;
3. for feasible systems, reallocate the potential fishing days and compute the net economic gain to the skipjack fleet; and
4. find the "best" feasible system in each class of systems, i.e., the one producing the greatest net economic gain to the skipjack fleet.

Under each system configuration the delivery scheme was simulated and costs were computed for increasingly longer "delivery seasons," beginning with a 1 month season coinciding with the period of highest opportunity cost and incrementing by periods of 1 month. Thus the performance of each configuration was examined under 3, 6, 9,..., 36 shipments. As expected, unit costs were inversely related to the scale of the system or number of shipments. Some system configurations were infeasible when run on a small scale, but feasible when more shipments were made. In some cases systems were judged to be feasible when of moderate scale, and then infeasible when enlarged because the bait delivered would exceed the estimated maximum amount usable by the present fleet. In all cases when simulated operations were expanded, the extension was into the month with the highest opportunity cost among the months still not included in the "delivery season."

SYSTEM CONFIGURATIONS

System configurations were created by varying certain model assumptions and conditions, as follows:

A. Survival Rates

1. Without aging
   a. Transport survival rate = 35%
   b. Transport survival rate = 50%
   c. Transport survival rate = 65%
2. With aging (aging survival rate = 45%)

a. Transport survival rate = 50%

b. Transport survival rate = 65%

c. Transport survival rate = 80%

B. Level of Capital Investment

1. 1-tanker system

2. 2-tanker system

3. 3-tanker system

4. 4-tanker system

C. Size of Bucket of Nehu

1. Standard - 7 pounds of nehu per bucket

2. 50% greater - 10.5 pounds of nehu per bucket

D. Relative Attractiveness

1. Standard - equal attractiveness

2. Pound for pound, anchovy only 67% as attractive as nehu

E. Skipjack Abundance

1. Standard - average abundance

2. Abundance 50% greater than average

3. Abundance 35% less than average

These alternative conditions combine in 288 ways. Each configuration was run under the 12 alternative "delivery seasons," so a total of 3,456 RO/RO systems were evaluated. The computations were done with the aid of a computer program.

RESULTS

BEST FEASIBLE SYSTEMS

The best feasible RO/RO systems among the cases examined are described in Table 4. The table gives estimates of the optimum number of shipments, the average unit delivery cost, the average net gain to the skipjack fleet and the average annual operating cost for each level of capital investment and each combination of assumptions on size of a nehu bucket, relative attractiveness, skipjack abundance and transport survival rate under the aging and no-aging options. Note that the actual capital investment is far greater for systems with aging than for those without.

The essential features of the table showing best feasible systems are summarized in Table 5. This gives the estimated net gain and unit production costs for 4-tanker systems under good, average and poor skipjack fishing years, under the most optimistic, most probable and most pessimistic conditions on bucket size and relative attractiveness (of those examined), and under the different aging and survival situations.

The analysis shows that during a year of average skipjack abundance a net gain to the fleet of about $385,000 could be achieved <u>under the most optimistic set of conditions</u>, and a gain as high as $810,000 might be obtained in a year of high skipjack abundance.

Under the most probable set of assumptions on bucket size and relative attractiveness (10.5-pound bucket; equal attractiveness), the expected gain is substantial under moderate transport survival